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ANALYSIS

Prospective voluntary agreements for escaping techno-institutional lock-in

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Abstract

The paper looks for evolutionary policy responses to techno-institutional lock-in, a persistent state that creates systemic market and policy barriers to technological alternatives. We address the coordination role for authorities rather than corrective optimisation and elaborate three evolutionary policy objectives, including fostering of (i) the diversity of technological options, (ii) common vision for the implementation of technological alternatives and (iii) changes in social and physical networks. We use these objectives to analyse documented experiences from environmental voluntary agreements and foresight activities. We argue that combining the virtues of these tools into a new policy tool, named *prospective voluntary agreement*, can help facilitate an escape from techno-institutional lock-in. The merit of the prospective voluntary agreement lies with the enhancement of collaborative policy cultures and inter-sectoral and interdisciplinary stakeholder learning that creates commitment to desired action for escaping lock-in.

Keywords: Environmental voluntary agreement; Foresight; Increasing returns; Lock-in; Path-dependence

1. Introduction

Conventional government response to environmental degradation has been the deployment of regulatory and market-based policy interventions to optimise the environmental and economic performance of existing production systems. Within such optimisation efforts, new voluntary policy tools have recently been developed, such as voluntary agreements, negotiated licenses and eco-labelling (OECD, 2000, 2003). However, a number of authors (e.g. Ayres, 1991; Carraro and Siniscalco, 1994; Smith, 2000; Kline, 2001) admit that optimisation-oriented approaches alone are unlikely to bring about sufficient change. Moreover, Unruh (2000, 2002) and Unruh and Carrillo-Hermosilla (in press) describe how such policies are partly responsible for *techno-institutional lock-in*, which creates market and policy barriers to environmentally superior technological alternatives. Hence, instead of optimisation, we focus on techno-institutional co-evolution and

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study voluntary policy tools as collaborative arrangements applied with the purpose of generating alternative technological pathways for discontinuity type of technological changes.

Among different types of voluntary tools, we focus on environmental voluntary agreements (EVA), defined as "*an agreement to facilitate action with a desirable environmental outcome, which is encouraged by government, to be undertaken by the participant based on the participant's self-interest*" (Storey et al., 1997). EVAs are typically negotiated between industry and government as alternatives to environmental regulation in an effort to generate faster environmental results and greater economic efficiency. They have been criticized, however, as lacking inclusiveness and having poorly defined targets, resulting in lower environmental standards, unenforceability and ineffectual monitoring (Makuch, 2003). Following Aggeri (1999) and Makuch (2003), we suggest that an enhanced learning *process* between authorities, industry and other stakeholders can help solve such shortcomings and, in particular, facilitate the generation of alternative technological pathways to escape techno-institutional lock-in.

In the field of innovation policy, stakeholder learning processes are inherent in technology assessment and *foresight* activities. While technology assessment (Eijndhoven, 1997; Hay and Noonan, 2000) recognises the potential impacts of existing technological choices, foresight emphasises learning and vision-building for designing a desirable and even radically different future. Foresight is typically employed to enhance long-term sectoral, regional or national innovation activities (Salo et al., 2004). Recently, foresight activities have paid increasing attention to effective communication and extensive stakeholder participation. The High Level Expert Group appointed by the European Commission summarized these trends by defining foresight as (European Commission, 2002): "*A systematic, participatory, future intelligence gathering and medium-to-long-term vision-building process aimed at present-day decisions and mobilising joint action*". At its best, a foresight process creates a common vision for structural and technological changes towards sustainable development. However, difficulties often arise in transferring vision into action (Salmenkaita and Salo, 2004).

In this paper, we discuss the dynamics of techno-institutional lock-in, which can create barriers to sustainable development, and elaborate responding evolutionary policy objectives. With these objectives, we examine experiences from EVA and foresight activities and integrate them into a new policy tool, named *prospective voluntary agreement* (PVA). We posit that PVA can help facilitate an escape from techno-institutional lock-in and have positive impacts for environmental and innovation policy-making.

2. Policy objectives within techno-institutional co-evolution

In policy approaches addressing techno-institutional co-evolution, the main question is not optimisation and equilibrium, but endogenous path-dependent technological change within a context of co-evolving environmental, social and economic processes characterised by irreversibility and uncertainty (Llerena and Matt, 1999; Mulder and van den Bergh, 2001; Carrillo-Hermosilla, 2004; Frenken et al., 2004). In the domain of environmental sustainability, Unruh (2000, 2002) describes the existing conditions of techno-institutional lock-in, which is a persistent state that creates systemic market and policy barriers to technological alternatives, e.g. to carbon free energy production, and which occurs through combined interactions among technological systems and governing institutions. Such lock-in arises through path dependent co-evolution driven by increasing returns to scale, which Arthur (1989, 1990, 1994) has classified as scale economies, learning economies, adaptive economies and network economies. Increasing returns mean that the earlier superiority and emergence of dominant design (Nelson, 1995) is no guarantee of long-term suitability (David, 1989; Nelson, 1994). Apparently production systems can become locked into inferior designs through a historically dependent process in which circumstantial events in the techno-institutional context can determine the winning alternative (David, 1985, 1997).

A Techno-Institutional Complex (TIC) is a highly co-evolved system where the members of the system create rules and practices to foster its self-perpetuation. Importantly government ministries and regulatory agencies are part of the TIC and are active participants in its perpetuation. Governments become involved in the establishment and extension of technological systems such as roadways and electricity grids for a variety of reasons including universal service, national security, and public safety among other justifications. Co-evolution among the private owners of technology and regulatory institutions fosters a stable system that can predictably provide needed services to society. However, in the case of many sustainability challenges, negative externalities associated with a given technology are belatedly discovered after the system is well established. This is currently the case for many energy, transportation, industrial and agricultural technologies and the basis of many current environmental challenges such as climate change, resource depletion and anthropogenic impacts on the planet's biogeochemical cycles. Overcoming these problems generally requires changes to the underlying technological systems. But such change can be impeded by techno-institutional lock-in.

The limits of technological change lie generally not with science and technology, which tend to evolve much faster than governing institutions, but with the organisational, social and institutional changes that facilitate or inhibit the diffusion of new technological solutions (Unruh, 2000). Technological change can be classified as either continuity or discontinuity type change. Such definitions, however, vary greatly depending on a chosen perspective such as competence and resource requirements, physical changes in the product or changes in price and performance (Ehrnberg, 1995). Moreover, what is discontinuous at one level of analysis may appear continuous at a higher level of analysis (Unruh, 2002). Within our analysis of techno-institutional systems, we define *continuity type of changes* as incremental competence enhancing changes or additions to components that preserve the overall technological architecture and sustain existing value networks. Correspondingly, *discontinuity type of change* is competence destroying radical change that seeks the replacement of an existing technological system and the creation of a new value network (Anderson and Tushman, 1990).

Historically, environmentally related change has been of the continuity type, such as end-of-pipe technologies that leave the production system basically intact and add pollution control equipment at the end of the process. These types of changes account for 70% to 90% of environmental technology expenditures (OIG, 2000). However, it is becoming clear that some environmental problems cannot be effectively solved through continuity approaches (Hawken et al., 1999; McDonough and Braungart, 2002). Dealing with global climate change, for example, will require nearly 90% reductions in carbon dioxide emissions by industrialized countries, something that currently appears to be beyond the scope of continuity approaches in the energy sector.

Given the internally generated stability, breaking the lock-in situation often requires exogenous pressures, which originate outside of the techno-institutional complex in the form, for example, of major crises or external shocks (Hughes, 1987; March and Olsen, 1989). Some examples of exogenous pressures include technological breakthroughs, social movements or environmental disruptions (Unruh, 2002). However, waiting for exogenous forces to initiate discontinuous change can be inefficient in resolving environmental problems. Many of environmental changes are irreversible, such as species extinction or abrupt shifts in global climate. Moreover, the impacts of technology on the environment and society are multi-faceted and may be noticed much later than in the emergence of technology, e.g. detrimental impacts of chlorofluorocarbons on the ozone layer.

Therefore, precautionary and responsive actions that allow evolution of the policy regime are needed to confront environmental problems (Unruh, 2002). In such a context, the role assigned to authorities is not corrective but *coordinative* (Metcalfe, 1995); as they are more concerned with facilitating technological and structural changes than imposing a particular result. In particular, escaping techno-institutional lock-in in the absence of exogenous shocks requires the generation of forces for desired discontinuity type of changes. Hence, the goal becomes a shift away from corrective optimisation-oriented public and private policies that reinforce lock-in conditions, to evolutionary policies that foster restructuring of industries and technological change. In this case the emphasis is on mutual learning and coordination in the combined use of regulatory, economic and voluntary policy tools. We elaborate three general policy objectives that address techno-institutional co-evolution and can help facilitate an escape from lock-in, including fostering (i) the diversity of technological options, (ii) a common vision for the implementation of technological alternatives, and (iii) changes in the physical and social networks.

2.1. Diversity of technological options

Technological development can be understood as an evolutionary process in which alternative technologies compete with one another and with the dominant technology to select winners and losers with considerable uncertainty at the outset to their individual social merits (Nelson and Winter, 1982). Here, enhancing the diversity of technological options is fundamental for adaptive flexibility and evolutionary potential of technological systems (Rammel and Van den Bergh, 2003).

The diversity of *technological options* includes both *physical technologies* in the form of technological artefacts and infrastructures, and *social technologies* (Nelson and Sampat, 2001) such as routines, hierarchies and institutions. The development and diffusion of such options, however, are frequently hampered by the dynamics of TIC. Hence, authorities often use regulatory, economic and voluntary policy tools to encourage stakeholder actions to expand the diversity of technological options and trajectories, and engage in learning about their respective social merits (Metcalfe, 1995; Kemp, 1997; Carrillo-Hermosilla, 2004; Frenken et al., 2004). In addition to ongoing research efforts into individual environmental technologies, cross-disciplinary and cross-sectoral collaboration can help increase the diversity of options and their creative combination in a systemic innovation process (e.g. integration of technology push and market pull approaches) that can help meet and shape market needs in ways that correct negative externalities.

2.2. Vision for implementation

Escaping lock-in requires implementation plans for technological alternatives that can replace existing technological architectures and create new value networks. However, the emergence of such implementation plans can be impeded by the inertia of TIC and sectorally fragmented, optimisation-oriented policies which lead to inefficient and counterproductive policy actions (Carraro and Siniscalco, 1994). In general, incumbent industries are prone to inertia as they tend to focus on the exploitation of existing dominant designs and the refinement of internal processes and routines rather than exploring alternative technologies and markets (Van de Ven, 1986; Tushman and O'Reilly, 1997). Moreover, Salmenkaita and Salo (2002) posit that because the generation and assimilation of future-oriented information may entail high costs, innovation systems may suffer from 'anticipatory myopia' which warrants publicly sponsored foresight activities.

By initiating processes for creating foresight and systemic understanding of techno-institutional co-evolution, authorities together with stakeholders (e.g. companies and research organisations) can begin to formulate pathways to alternative technological arrangements. Vision building entails the creation of future-oriented scenarios that envision the new technologies, their systemic interconnections and the new institutional arrangements necessary for their successful adoption. This vision can then guide the physical and organizational changes needed to escape a lock-in condition. Here, we turn our focus to innovation policy and, in particular, foresight activities designed for improving the understanding of entire innovation systems.

2.3. Changes in physical and social networks

Munir and Phillips (2002) point out that technological discontinuities are characterised with the restructuring of industrial boundaries and the emergence of competing coalitions and competing technological systems. Therefore, implementing visions of discontinuity type of changes requires a redefinition of stakeholder roles and institutional structures, as well as actual changes in the technological systems of concern. Both policy-makers and other stakeholders tend to shape institutional context through their strategic actions of creating and claiming value (Powell and DiMaggio, 1991), often through the formation of new coalitions. However, collaborative action can also be used for enforcing TIC (Beder, 1998) which impedes the creation of new value networks through self-perpetuating corporatist policy making (Galbraith, 1967).

Particular policy efforts can facilitate the creation of inter-sectoral collaborative behaviour that can foster the implementation of discontinuity changes. Thus, authorities can initiate future-oriented and facilitated processes that encourage corporate initiatives that break traditional industry boundaries. This process can be enhanced by engaging actors from outside the TIC that provide new alternatives and motivations. This can ultimately lead to the formation of new coalitions with different value networks and the development of radically new technological arrangements. Policy actions may spur the emergence of such competing coalitions by supporting the simultaneous development of different architectures, configurations, features and standards (Tushman and O'Reilly, 1997). Here, experiences on EVA can provide insight into how industry commits to desired action by building on incentives and collaboration, without ruling out regulatory actions in case of non-compliance.

3. Environmental voluntary agreements and foresight activities

Both EVA and foresight activities can be seen as stakeholder learning processes that can support the attainment of the evolutionary policy objectives. Before examining the possibilities to combine the virtues of foresight and EVA we provide a short overview of both fields. They represent distinct approaches to policymaking. EVA are designed to curb negative impacts of technology and polluting industrial activities, whereas Foresight activities focus traditionally on technological advance that improves economic competitiveness. For the comparative analysis, we use triadic categorisations of both fields and identify the most suitable practices for the elaboration of a new evolutionary policy tool.

3.1. Environmental voluntary agreements

EVA are typically designed as alternatives to stricter regulatory actions. Thus, research on EVA tends to focus on environmental results and economic efficiency within a specific institutional context (OECD, 2000). Our interest, however, lies particularly in the collaborative mechanism of EVA that can be conducive to the development of innovative solutions, which authorities and companies would have been unlikely to develop separately. OECD (2000) has classified EVA in three categories, including (i) unilateral agreements initiated among industry, (ii) public voluntary programmes devised by regulators and (iii) negotiated agreements drafted between regulators and industry. Next, we follow this triadic categorisation and outline some of the experiences from each of them in relation to the evolutionary policy objectives.

3.1.1. Unilateral agreement

Unilateral agreements are generally commitments by industry to reduce pollution. Thus, these commitments do not necessitate the involvement of authorities (OECD, 2000). Typically unilateral agreements emerge as a response to stakeholder pressures to gain legitimacy and to avoid stricter regulation, for example, the Responsible Care Program in the chemical industry (Howard et al., 2000) and the Declaration on Global Warming Prevention adopted in 1996 by German industry and trade (Christoph Böhringer and Frondel, 2002). The former represents intensive collaboration in a specific sector facing growing stakeholder pressures, whereas the latter is a loose coalition among different sectors to avoid the implementation of an energy tax. Thus, unilateral agreements tend to contribute to the self-perpetuation of existing TIC. Technological options, vision building and social and physical changes are generally limited to incremental improvements of present production systems.

3.1.2. Public voluntary programmes

Public voluntary programmes are devised by authorities who establish a framework and define the basic requirements for participation. These programmes usually provide incentives such as technical assistance and positive public recognition to participating companies (OECD, 2000). Most of EVA in U.S. are public voluntary programmes, as these programmes do not necessitate sectoral industry coalitions or agreement negotiations with authorities. For example, in the Design for Environment Program (DfE), the U.S. Environment Protection Agency (EPA) developed and provided companies with information how to incorporate environmental issues into the design of products, processes and management systems (Delmas and Terlaak, 2001a). The programme emphasised information dissemination and coordination of research and technology development (RTD) efforts. Within public voluntary programmes, industry-research collaboration creates a diversity of technological options and changes in social networks, but does not enforce the implementation of technological alternatives and new value networks, especially, as it does not contain environmental targets or sanctions. The corporate level targets emerging from the EPA's Climate Wise Programme, for example, do not necessitate discontinuity type of changes for their attainment (Delmas and Terlaak, 2001b). As public voluntary programmes tend to be designed by authorities with limited stakeholder interaction, visions for implementation of technological alternatives remain fragmented and often limited in scope.

3.1.3. Negotiated agreements

Negotiated agreements differ from unilateral agreements and public voluntary programmes, in that they require negotiation between industry and authorities (OECD, 2000). The success of negotiated agreements in fostering discontinuity changes in physical and social networks relies largely on credible regulatory commitment, which may be diminished by the fragmentation of decision-making power among different authorities and the open access of stakeholders in negotiations (Delmas and Terlaak, 2001b). When stakeholders are included, transaction costs may become prohibitive. For example, in U.S. EPA's Project XL (eXcellence and Leadership), stakeholder involvement entailed lengthy and costly negotiations (Blackman and Mazurek, 2000). Thus, wider stakeholder engagement is typically seen as a burden rather than a learning opportunity. Still, stakeholder participation and transparency of negotiations remain important for achieving legitimacy and the efficient implementation of an agreement (European Commission, 1996).

Negotiated agreements may be designed to increase the diversity of technological options and changes in social networks. For example, the French End-of-Life-Vehicle Agreement emerged from a problem too complex to be handled by a single company or industry (Aggeri, 1999). Collaboration was needed to create a coordination mechanism, which promoted learning and exploratory action. Furthermore, the targets of the agreement asked for changes in technological trajectories and mutual knowledge formation between companies (Delmas and Terlaak, 2001a). Still, in negotiated agreements, limited attention is paid to the generation of alternative pathways and vision-building for their implementation.

3.2. Foresight activities

In recent years, national, regional and sectoral foresight studies have been conducted in many countries, in order to define research priorities, discuss the future from a broad range of complementary viewpoints and create common vision for RTD activities (Gavigan, 2002; Hjelt et al., 2001). The locus of foresight activities has shifted from positivist and rationalist technology-focused approaches towards the recognition of broader concerns that consider the entire innovation system, including the challenge of sustainable development (Gavigan, 2002; Schomberg, 2002). Along this line, increasing attention has been paid to communication and stakeholder engagement, which is inherent in the definition of foresight. Salmenkaita and Salo (2004) distinguish foresight activities between forms of (i) emergent foresight driven by stakeholder interests to align RTD activities, (ii) embedded foresight conducted within instruments of innovation policy and (iii) explicit foresight initiated by policy-makers to align innovation policy actions. Subsequently, we discuss these practices in relation to the evolutionary policy objectives.

3.2.1. Emergent foresight

Salmenkaita and Salo (2004) define emergent foresight as "collective and competitive processes through which future-oriented analyses are iteratively produced, revised and evaluated, in response to a recognized need to align interdependent RTD agendas with opportunities that are perceived and shaped by stakeholders who share overlapping interests". Emergent foresight occurs typically within industry clusters, often with no involvement of authorities. For example, the work of the Wireless World Research Forum (WWRF) – which sought to promote the conception, development and diffusion of wireless communication technologies – evolved from the establishment of a think-thank into a forum consisting of open calls for proposals, open meetings and workshops.

In this kind of networking process participants synthesise their competing and complementary views through iterative discussions into increasingly comprehensive visions of the future that may accelerate changes in physical and social networks and the development of new technological options for shaping future markets (Salmenkaita and Salo, 2004). However, because emergent foresight is often initiated around existing industry coalitions, claiming value and competitive strategies are frequent and can limit attention on long-term institutional changes required for successful implementation.

3.2.2. Embedded foresight

Embedded foresight refers to "individual and collaborative processes through which prospective information about relevant technological, commercial and societal developments is acquired, produced, refined or communicated within RTD programmes, in order to generate shared vision for RTD activities" (Salo and Salmenkaita, 2002). For example, foresight activities embedded within Finnish RTD programmes in electronics and telecommunication have been highly relevant, because the sectors are characterised by rapid technological advance (Salo and Salmenkaita, 2002). Foresight activities embedded in steering group meetings and project reviews induce changes in social networks among the funding agencies, the recipients of RTD funding and the consulted experts and, thus, also accelerate the development of new technological options. However, embedded foresight often is limited to the areas of existing RTD activities in terms of a time horizon and vision-building and, thus also with regards to the scope of changes in physical and social networks.

3.2.3. Explicit foresight

Explicit foresight exercises in support of innovation policy-making exhibit considerable variety within the used methods. Salmenkaita and Salo (2004) consider explicitly managed foresight projects "where (i) the setting of research priorities is among the key agenda items, (ii) the work is intensively systematic and analytic, and (iii) participants are consulted mainly due to their expertise in specific fields". Such exercises often are run by appointing parallel expert panels (e.g. Keenan, 2003). Although the process itself may not ensure that steps towards the implementation of recommendations are taken, the results can be used to justify changes in S&T priorities. This may create changes in physical and social networks and influence on the development of alternative technological arrangements. For example, the UK Technology Foresight lead to the launch of several new LINK (academic-industrial collaborative RTD) programmes, e.g. waste minimisation through recycling, reuse and recovery in industry (Georghiou et al., 1998).

In explicit foresight, sustainable development is generally viewed as a key future need to which science and technology should be directed. However, threats related to technological advance tend to be neglected (Hjelt et al., 2001). This disregards the viewpoint inherent in environmental technology assessment (Eijndhoven, 1997; Hay and Noonan, 2000). As a promising exception, an explicit foresight initiated by the Dutch Ministry of Housing, Physical Planning (Borup, 2003) discussed future technologies as opportunities for systemic changes but also as potential sources for new environmental problems. In explicit foresight, especially the selection of participants plays an important role in order to induce creative discussion and challenge the existing TIC.

3.3. Conclusions on environmental voluntary agreements and foresight

The triadic categorisations of EVA and foresight activities focuses on the role of authorities and may be used as a starting point for examining the possibilities to combine EVA and respective foresight activities into an integrated policy tool. Unilateral agreements and emergent foresight are both typically industry-lead activities in which authorities are observers and they have limited access and limited possibilities to foster the attainment of evolutionary objectives. Public voluntary programmes and embedded foresight are designed and initiated by authorities, but with limitations in terms of time, scope and stakeholder engagement. In negotiated agreements and explicit foresight, authorities, in turn, have a major role in the facilitation of a learning process that engages different stakeholders (see Table 1). Authorities thus work as facilitative leaders who participate in the process simultaneously as a negotiation party and facilitator of

Table 1
The roles of authorities in relation to EVA and foresight activities

Role of authorities	Environmental voluntary agreement	Foresight
Observer	Unilateral agreement	Emergent foresight
Designer	Public voluntary program	Embedded foresight
Facilitator	Negotiated agreement	Explicit foresight

mutual learning and common vision-building among stakeholders. Therefore, because the evolutionary policy objectives calls for authorities to actively engage in learning and the coordination of stakeholder processes, we consider combining negotiated agreement and explicit foresight the most suitable area to work on.

Negotiated agreements typically focus on environmental targets with little constrains on how the targets are achieved technologically (OECD, 2000). Thus, the impacts on the diversity of technological options depend largely on participants' strategic assessment and the competitive implications of continuity and discontinuity type alternatives. Here, explicit foresight provides an array of methods for considering alternative technological options.

In negotiated agreements, issues negotiated between incumbents or industry federations and authorities tend to be defined at the out-set of the process, leaving little space for learning and vision-building (OECD, 2000). Hence, negotiated agreements are frequently limited to eco-efficiency targets in disregard of other policy objectives (Blackman and Mazurek, 2000). Here, the deployment of methods used in explicit foresight activities enable facilitated and future-oriented learning and vision-building process that helps participants – especially from industry, research and public sector but also from civil society – to explore, identify, define and stay focused on the visioning of technological pathways and new value networks.

Negotiated agreements are often supported by mediation — which helps the parties to work out their own mutually agreeable targets and commit to them (Raiffa, 1982). Still, they are constrained by current institutional pressures and, thus, prone to degrade into competitive value claiming or succumb to regulatory capture. Explicit foresight, in turn, is a *decision support* rather than *decision-making* process, which reduces the need for lobbying and value claiming and assists participants to work together, even those with conflictive histories (Raiffa, 1982).

4. Prospective voluntary agreement

Within the conditions of techno-institutional lock-in, authorities often need to consider and foster discontinuity changes that typically entail high uncertainty. In such cases policy-makers may consider combining virtues of negotiated agreement and explicit foresight. By combining these approaches, authorities can maintain the credible threat of environmental regulatory actions as well as innovation-oriented economic incentives that can bring together even confrontational stakeholders into a mutually beneficial learning and commitment to action. To achieve this integration, we propose the development of a new integrated policy tool termed the *Prospective Voluntary Agreement* (PVA). Based on the general definitions on EVA and Foresight in Section 1 and the specific characteristics of negotiated agreement and explicit foresight, we characterize PVA as follows:

When confronted by high complexity and uncertainty on the technological and institutional advances related to desired discontinuity changes, authorities may broadly engage stakeholders in a systematic, future-oriented intelligence gathering and medium-to-long-term vision-building process. This process is aimed at creating an agreement between contracting parties, in particular between authorities and industry, to facilitate collaborative action directed towards the creation of (i) a diversity of technological options, and (ii) a vision for the implementation of technological alternatives that facilitates (iii) desired changes in the physical and social networks. The outcome will ultimately define long-term targets, responsibilities, monitoring, rules and possible sanctions in case of incompliance.

We advocate the use of PVA in the situations where high complexity and uncertainty on technological and institutional advances necessitate learning and enhanced stakeholder coordination. EVA have been applied in such uncertain and complex situations, especially to anticipate the enforcement of European Union directives or national regulations

(Makuch, 2003). Even if typical in EVA, the optimisation of environmental and economic performance within present production systems is not, however, the aim of PVA. A PVA process focuses on the future-oriented learning and commitment of different stakeholders to foster the implementation of alternative technological arrangements. While the PVA process engages a diverse set of stakeholders, the agreement is contracted only between authorities and specific stakeholders crucial for the implementation and diffusion of new technology arrangements. Such arrangements should anticipate and create future markets and institutional arrangements in a national or regional level.

Recognising the challenge of integrating two different policy approaches, here we focus on the management of the stakeholder learning process that supports the drafting a PVA, thus, giving limited attention to post-negotiation activities such as monitoring. In Table 2, we summarise the main dimensions of an archetypal negotiated agreement and explicit foresight and their respective combined determinants for an archetypal PVA. PVA relies on the extensive stakeholder learning process to create a foundation for the negotiation of an agreement between key stakeholders. Correspondingly, the activities of project coordinators evolve over the process from facilitation to mediation. Instead of fixing issues at the out-set of the process, divergence and convergence of views on future challenges are looked for and elaborated through cycles of learning and negotiation. During this vision-building process key issues are identified for drafting an agreement that defines stakeholder commitment for future action.

Here, we consider an empirical case, which corresponds at least to some of the dimensions relevant to PVA and to the evolutionary policy objectives. Aggeri (1999) and Delmas and Terlaak (2001a) have discussed the collective learning approach chosen in the French end-of-life vehicles (ELV) framework agreement as a response to the issues of car waste management emerging in the European policy agenda in the early 1990s. In this process, the French Ministries of Industry and Environment negotiated the agreement with two French car manufacturers, twelve importers and eight trade associations including the dismantlers, shredders and recyclers, material producers and equipment suppliers. The focus was on the treatment of end-of-life vehicles, and design of cars to improve the recovery, re-use and recycling of materials. The agreement started in 1993 with general targets including: (i) no more than 15% of total car weight land-filled by 2002 (maximum of 200 kg), (ii) no more than 5% in the long term, and (iii) from 2002, new models must allow 90% recovery, re-use or recycling. The targets and the agreement were widely accepted by 24 signatories. There were no explicit sanctions but the Ministries held the implicit threat of future legislation. The key mechanism for the achievement of targets was based on the distribution of responsibilities, for example through certification schemes developed for dismantlers and shredders. Certification was required to do business with other large parties (e.g. car companies and insurers) (EEA, 1997; Aggeri, 1999).

The agreement emphasised shared responsibility, engaging all the actors in the sector to collective learning and problem-solving. In contrast, the German approach to the same challenge demanded very ambitious targets for different materials for ELVs and made manufacturers solely responsible for ensuring they were met. In the French case, not only dismantlers, shredders, recycling companies and experts, cement industry and haulage companies engaged, but also manufacturers and authorities were involved with the elaboration of new technologies, new working

Table 2
Dimensions of archetypal negotiated agreement, prospective voluntary agreement and explicit foresight

Dimensions	Archetypal negotiated agreement	Archetypal prospective voluntary agreement	Archetypal explicit foresight
Collaboration	Negotiation and decision-making	Cycles of learning, negotiation and decision-making	Learning and support for decision-making
Stakeholder engagement	Limited to industry and authorities	Structured stakeholder engagement	Inclusion of industry, research, authorities and other stakeholders
Process management	Negotiation and mediation	Facilitation and mediation	Facilitation
Outcomes	Commitment to action	Vision and commitment to action	Vision

methods and new forms of organisation (Aggeri, 1999; Delmas and Terlaak, 2001a).

4.1. Cycles of learning and negotiation

The PVA process builds on stakeholder learning and facilitation methods used in explicit foresight in order to avoid the premature definition of issues typical to negotiated agreements. Only after creative formulation of various alternative technological pathways the process is directed toward the identification of key issues and focused negotiations for an agreement between key stakeholders. The design of creative learning and negotiation process calls for authorities to take an active role by providing needed infrastructure and bargaining power for the process. The combined use of foresight and negotiation methods balances analytic (quantitative) and communicative (qualitative) approaches (Salo et al., 2004). However, the selection of these approaches and methodological choices is difficult, because the different methods (e.g., Delphi-survey, critical technologies, expert panels, see, e.g. Porter et al., 1991) have their specific advantages and disadvantages. Thus, in the management of the PVA process, coordinators need to pay attention to responsiveness to the interests and expectations of participating stakeholders, and flexibility in planning and implementation through cycles of learning and decision-making (Salo et al., 2004). For example, the French ELV case developed iteratively from an initial framework for establishing collaboration among stakeholders toward drafting complementary arrangements such as rules, technical standards, procedures and contracts (Aggeri, 1999).

4.2. Structured stakeholder engagement

The attainment of evolutionary objectives calls for wide stakeholder participation to engage actors also from outside the TIC. However, experiences both from negotiated agreements and explicit foresight indicate that wide stakeholder engagement may become too complex and controversial to manage (Blackman and Mazurek, 2000; Hjelt et al., 2001). Based on the encouraging experiences from structured stakeholder engagement in a foresight study (Salo et al., 2004), we elaborate three levels of stakeholder engagement in PVA process, addressing which stakeholders are placed into contact with each other and how learning and vision-building emerge:

- *Low engagement*: Stakeholders exchange ideas and perceptions on future challenges in seminars and individual interviews, thus contributing inputs to the process which, however, does not necessarily lead to notable changes in their value networks.
- *Medium engagement*: Stakeholders participate also in workshops and meetings engaging in collaborative learning processes and proactive development of radical technological options which also create shifts in participants' value networks (this, however, does not necessarily lead to participation in the agreement).
- *High engagement*: Key stakeholders are intensively involved in the collaborative management of the whole process. Through iterative process cycles of learning and decision-making key stakeholders create a common vision for drafting a workable PVA among contracting parties.

With high engagement, the key stakeholders – namely authorities and industry representatives– design and manage together the cyclic and iterative learning and decision-making process. They can also invite extensively stakeholders in low and medium engagement to support the process. This enables the intersectoral and interdisciplinary participation of experts and responds to the need for the inclusion of participants outside the TIC. High engagement, in turn, creates trust and commitment among the key stakeholders, minimising the transaction costs and the likelihood of free-riding (Blackman and Mazurek, 2000). Such structured stakeholder engagement might have been beneficial also for French ELV negotiations, where the inclusion of stakeholders from various sectors motivated the elaboration of new technological options, pathways and new value networks.

4.3. Facilitation and mediation

The PVA begins with facilitated learning processes typical for explicit foresight, mapping present and future challenges e.g. through interviews, queries and scenario working (e.g. Porter et al., 1991). Coordinators facilitate the mutual learning that prepares contracting parties for agreement negotiations. Creativity of PVA process may be fostered with different considerations: (i) by separating the ideation of alternative technological options and pathways from their evaluation, (ii) by encouraging participants to share ideas, interests and expectations, for example through the provision of small group work, anonymous feedback, ample time for reflection and information processing, and (iii) by acknowledging the plurality of values (Higgins, 1994; Salo et al., 2004). In the negotiations of an agreement, the coordinators move from facilitation to mediation, helping key stakeholders to identify and compare decision alternatives and work out their own a workable agreement (Raiffa, 1982). However, the use of such neutral third-parties is not typical in voluntary agreement negotiations. Nevertheless, it is common that foresight activities are managed by coordinators, who work as facilitators bringing in the process structure and methodological expertise.

4.4. Vision and commitment to action

Combining explicit foresight and negotiated agreement enables establishing, on the one hand, an open forum for stakeholder learning and the creation of systemic understanding of present and future challenges, and on the other hand, a common platform for key stakeholders to negotiate an agreement leading to action for escaping lock-in. The drafted agreement itself, however, is no more than a formal point in a process that commits key stakeholders to desired action. Thus, the agreement should be seen as a confirmation and reinforcement of the value of the emerged cooperation. For example, in the French case, according to Aggeri (1999) authorities and manufacturers negotiated a framework agreement which set out (i) quantitative processing targets which did not specify the type of technology to be used, (ii) a principle to share responsibility involving all the actors in the sector, (iii) rules for transferring know-how, (iv) confirmation of the principle of a free market, and (v) the introduction of follow-up committees for monitoring. This framework agreement provided common bases for establishing new collaborative relations which later on lead to contracting additional arrangements among stakeholders; for example, to create new markets for recycled products. In hindsight, the deployment of foresight methods before drafting the framework agreement could have provided relevant new understanding for the generation of discontinuity type of changes, fostering systemic impacts within the whole sector of mobility and transport.

5. Discussion

In this paper, we elaborated evolutionary policy responses to techno-institutional lock-in, arguing for a coordination role for authorities rather than the corrective optimisation. Within a techno-institutional complex existing government policy is partially responsible for inertia to technological change. Thus, in the absence of exogenous shocks, escaping lock-in requires continuous learning among stakeholders and the inclusion of actors also from outside the TIC. In this context, we identified the need for authorities to initiate future-oriented stakeholder processes to generate alternative technological pathways for discontinuity type of technological changes.

Within the evolutionary objectives of fostering (i) the diversity of technological options, (ii) common vision for the implementation of technological alternatives and (iii) changes in social and physical networks, we examined EVAs and Foresight activities. We identified their individual virtues and shortcomings and developed a new integrated policy tool, PVA; in which authorities can use the threat of environmental regulatory actions as well as innovation oriented economic incentives to connect even confrontational stakeholders into a mutually beneficial creative learning process and commit them to desired future action. The merit of PVA process lies with the enhancement of collaborative policy culture and inter-sectoral and interdisciplinary stakeholder learning. Thus, in the application of PVA in a specific policy context, particular attention should be paid to the creation of a new collaborative arrangement that emerges from the existing institutional structures but recognises also the key role of actors outside the TIC and the plurality of viewpoints. At best, PVA process helps participants to position themselves in relation to TIC, allowing them to take informed decisions for the creation of radically new options and changes in physical and social networks. It also helps consolidate a shared vision for implementation of technological alternatives that supports the development of joint action plans.

We consider our exploratory work on combining the virtues of foresight and EVA providing further directions to continue also the work of Aggeri (1999), which looked at environmental voluntary agreements as collaborative learning processes. The introduction of foresight methods in EVA can also help synchronise environmental and innovation policy fields. For example PVA could be applied within the context of European technology platforms, in which government can engage, not only as a sponsor of R&D, but also in its capacity as a regulator and standard setter (Georghiou et al., 1999; European Commission, 2004). In general, we suggest further development of PVA approach within the both fields of negotiated agreement and explicit foresight: within the former it calls for the inclusion of a future-oriented stakeholder learning process before fixing the scope and issues for agreement negotiations and within the latter it extends the locus from decision support towards decision-making, thus also committing key stakeholders to desired action. Therefore, we call for the creation of empirical evidence on PVA by initiating such processes and case studies for policy learning and further methodological development. We elaborated PVA to escape techno-institutional lock-in, but it may well provide support also for precautionary action to prevent the emergence of lock-in conditions. Finally, although we focused on integrating the virtues of explicit foresight and negotiated agreement, we consider also combining the virtues of unilateral agreement and emergent foresight as well as public voluntary programme and embedded foresight relevant areas for future work.

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